

GLUCOSINOLATES: REGULATION OF BIOSYNTHESIS AND HYDROLYSIS

EDITED BY: Ralph Kissen, Tamara Gigolashvili and Naveen C. Bisht
PUBLISHED IN: Frontiers in Plant Science





frontiers

Frontiers eBook Copyright Statement

The copyright in the text of individual articles in this eBook is the property of their respective authors or their respective institutions or funders. The copyright in graphics and images within each article may be subject to copyright of other parties. In both cases this is subject to a license granted to Frontiers.

The compilation of articles constituting this eBook is the property of Frontiers.

Each article within this eBook, and the eBook itself, are published under the most recent version of the Creative Commons CC-BY licence.

The version current at the date of publication of this eBook is CC-BY 4.0. If the CC-BY licence is updated, the licence granted by Frontiers is automatically updated to the new version.

When exercising any right under the CC-BY licence, Frontiers must be attributed as the original publisher of the article or eBook, as applicable.

Authors have the responsibility of ensuring that any graphics or other materials which are the property of others may be included in the CC-BY licence, but this should be checked before relying on the CC-BY licence to reproduce those materials. Any copyright notices relating to those materials must be complied with.

Copyright and source acknowledgement notices may not be removed and must be displayed in any copy, derivative work or partial copy which includes the elements in question.

All copyright, and all rights therein, are protected by national and international copyright laws. The above represents a summary only. For further information please read Frontiers' Conditions for Website Use and Copyright Statement, and the applicable CC-BY licence.

ISSN 1664-8714

ISBN 978-2-88966-372-9

DOI 10.3389/978-2-88966-372-9

About Frontiers

Frontiers is more than just an open-access publisher of scholarly articles: it is a pioneering approach to the world of academia, radically improving the way scholarly research is managed. The grand vision of Frontiers is a world where all people have an equal opportunity to seek, share and generate knowledge. Frontiers provides immediate and permanent online open access to all its publications, but this alone is not enough to realize our grand goals.

Frontiers Journal Series

The Frontiers Journal Series is a multi-tier and interdisciplinary set of open-access, online journals, promising a paradigm shift from the current review, selection and dissemination processes in academic publishing. All Frontiers journals are driven by researchers for researchers; therefore, they constitute a service to the scholarly community. At the same time, the Frontiers Journal Series operates on a revolutionary invention, the tiered publishing system, initially addressing specific communities of scholars, and gradually climbing up to broader public understanding, thus serving the interests of the lay society, too.

Dedication to Quality

Each Frontiers article is a landmark of the highest quality, thanks to genuinely collaborative interactions between authors and review editors, who include some of the world's best academicians. Research must be certified by peers before entering a stream of knowledge that may eventually reach the public – and shape society; therefore, Frontiers only applies the most rigorous and unbiased reviews.

Frontiers revolutionizes research publishing by freely delivering the most outstanding research, evaluated with no bias from both the academic and social point of view. By applying the most advanced information technologies, Frontiers is catapulting scholarly publishing into a new generation.

What are Frontiers Research Topics?

Frontiers Research Topics are very popular trademarks of the Frontiers Journals Series: they are collections of at least ten articles, all centered on a particular subject. With their unique mix of varied contributions from Original Research to Review Articles, Frontiers Research Topics unify the most influential researchers, the latest key findings and historical advances in a hot research area! Find out more on how to host your own Frontiers Research Topic or contribute to one as an author by contacting the Frontiers Editorial Office: researchtopics@frontiersin.org

GLUCOSINOLATES: REGULATION OF BIOSYNTHESIS AND HYDROLYSIS

Topic Editors:

Ralph Kissen, Norwegian University of Science and Technology, Norway

Tamara Gigolashvili, University of Cologne, Germany

Naveen C. Bisht, National Institute of Plant Genome Research (NIPGR), India

Citation: Kissen, R., Gigolashvili, T., Bisht, N. C., eds. (2021).

Glucosinolates: Regulation of Biosynthesis and Hydrolysis. Lausanne: Frontiers Media SA. doi: 10.3389/978-2-88966-372-9

Table of Contents

- 04 Editorial: Glucosinolates: Regulation of Biosynthesis and Hydrolysis**
Bhanu Malhotra and Naveen C. Bisht
- 07 Overexpressing the Myrosinase Gene TGG1 Enhances Stomatal Defense Against *Pseudomonas syringae* and Delays Flowering in *Arabidopsis***
Kaixin Zhang, Hongzhu Su, Jianxin Zhou, Wenjie Liang, Desheng Liu and Jing Li
- 21 Same Difference? Low and High Glucosinolate *Brassica rapa* Varieties Show Similar Responses Upon Feeding by Two Specialist Root Herbivores**
Rebekka Sontowski, Nicola J. Gorringer, Stefanie Pencs, Andreas Schedl, Axel J. Touw and Nicole M. van Dam
- 32 Glucosinolate Content in Dormant and Germinating *Arabidopsis thaliana* Seeds is Affected by Non-Functional Alleles of Classical Myrosinase and Nitrile-Specifier Protein Genes**
Kathrin Meier, Markus D. Ehbrecht and Ute Wittstock
- 46 Coordination of Glucosinolate Biosynthesis and Turnover Under Different Nutrient Conditions**
Verena Jeschke, Konrad Weber, Selina Sterup Moore and Meike Burow
- 63 Identification and Characterization of Three Epithiospecifier Protein Isoforms in *Brassica oleracea***
Katja Witzel, Marua Abu Risha, Philip Albers, Frederik Börnke and Franziska S. Hanschen
- 77 Corrigendum: Identification and Characterization of Three Epithiospecifier Protein Isoforms in *Brassica oleracea***
Katja Witzel, Marua Abu Risha, Philip Albers, Frederik Börnke and Franziska S. Hanschen
- 79 Both Biosynthesis and Transport are Involved in Glucosinolate Accumulation During Root-Herbivory in *Brassica rapa***
Axel J. Touw, Arletys Verdecia Mogena, Anne Maedicke, Rebekka Sontowski, Nicole M. van Dam and Tomonori Tsunoda
- 92 The Role of a Glucosinolate-Derived Nitrile in Plant Immune Responses**
Hieng-Ming Ting, Boon Huat Cheah, Yu-Cheng Chen, Pei-Min Yeh, Chiu-Ping Cheng, Freddy Kuok San Yeo, Ane Kjersti Vie, Jens Rohloff, Per Winge, Atle M. Bones and Ralph Kissen
- 110 Genomic Origin and Diversification of the Glucosinolate MAM Locus**
R. Shawn Abrahams, J. Chris Pires and M. Eric Schranz



The Role of a Glucosinolate-Derived Nitrile in Plant Immune Responses

Hieng-Ming Ting^{1*}, Boon Huat Cheah², Yu-Cheng Chen¹, Pei-Min Yeh¹, Chiu-Ping Cheng¹, Freddy Kuok San Yeo³, Ane Kjersti Vie⁴, Jens Rohloff⁴, Per Winge⁴, Atle M. Bones⁴ and Ralph Kissen^{4*}

¹ Institute of Plant Biology and Department of Life Science, National Taiwan University, Taipei, Taiwan, ² Department of Agronomy, National Taiwan University, Taipei, Taiwan, ³ Faculty of Resource Science and Technology, Universiti Malaysia Sarawak, Kota Samarahan, Malaysia, ⁴ Cell, Molecular Biology and Genomics Group, Department of Biology, Norwegian University of Science and Technology, Trondheim, Norway

OPEN ACCESS

Edited by:

Aleš Svatoš,
Max Planck Institute for Chemical
Ecology, Germany

Reviewed by:

Irene García,
Institute of Plant Biochemistry
and Photosynthesis (IBVF), Spain
Thomas Leustek,
Rutgers, The State University
of New Jersey, United States

*Correspondence:

Hieng-Ming Ting
jimmytinghm@ntu.edu.tw
Ralph Kissen
ralph.kissen@ntnu.no

Specialty section:

This article was submitted to
Plant Metabolism
and Chemodiversity,
a section of the journal
Frontiers in Plant Science

Received: 31 October 2019

Accepted: 19 February 2020

Published: 10 March 2020

Citation:

Ting H-M, Cheah BH, Chen Y-C,
Yeh P-M, Cheng C-P, Yeo FKS,
Vie AK, Rohloff J, Winge P, Bones AM
and Kissen R (2020) The Role of a
Glucosinolate-Derived Nitrile in Plant
Immune Responses.
Front. Plant Sci. 11:257.
doi: 10.3389/fpls.2020.00257

Glucosinolates are defense-related secondary metabolites found in Brassicaceae. When Brassicaceae come under attack, glucosinolates are hydrolyzed into different forms of glucosinolate hydrolysis products (GHPs). Among the GHPs, isothiocyanates are the most comprehensively characterized defensive compounds, whereas the functional study of nitriles, another group of GHP, is still limited. Therefore, this study investigates whether 3-butenenitrile (3BN), a nitrile, can trigger the signaling pathways involved in the regulation of defense responses in *Arabidopsis thaliana* against biotic stresses. Briefly, the methodology is divided into three stages, (i) evaluate the physiological and biochemical effects of exogenous 3BN treatment on *Arabidopsis*, (ii) determine the metabolites involved in 3BN-mediated defense responses in *Arabidopsis*, and (iii) assess whether a 3BN treatment can enhance the disease tolerance of *Arabidopsis* against necrotrophic pathogens. As a result, a 2.5 mM 3BN treatment caused lesion formation in *Arabidopsis* Columbia (Col-0) plants, a process found to be modulated by nitric oxide (NO). Metabolite profiling revealed an increased production of soluble sugars, Krebs cycle associated carboxylic acids and amino acids in *Arabidopsis* upon a 2.5 mM 3BN treatment, presumably via NO action. Primary metabolites such as sugars and amino acids are known to be crucial components in modulating plant defense responses. Furthermore, exposure to 2.0 mM 3BN treatment began to increase the production of salicylic acid (SA) and jasmonic acid (JA) phytohormones in *Arabidopsis* Col-0 plants in the absence of lesion formation. The production of SA and JA in nitrate reductase loss-of function mutant (*nia1 nia2*) plants was also induced by the 3BN treatments, with a greater induction for JA. The SA concentration in *nia1 nia2* plants was lower than in Col-0 plants, confirming the previously reported role of NO in controlling SA production in *Arabidopsis*. A 2.0 mM 3BN treatment prior to pathogen assays effectively alleviated the leaf lesion symptom of *Arabidopsis* Col-0 plants caused by *Pectobacterium carotovorum* ssp. *carotovorum* and *Botrytis cinerea* and reduced the pathogen growth on leaves. The findings of this study demonstrate that 3BN can elicit defense response pathways in *Arabidopsis*, which potentially involves a coordinated crosstalk between NO and phytohormone signaling.

Keywords: secondary metabolites, glucosinolates, nitriles, metabolomics, transcriptomics, plant innate immunity